Progress Report for July 1962

EVALUATION OF REGENERATIVE FUEL CELL

Prepared for

National Aeronautics and Space Administration
Western Operations Office
150 Pico Boulevard
Santa Monica, California

Contract NAS 7-181

EOS Report 3310-ML-1 14 August 1962

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CONTENTS

1. SCOPE OF THE PRESENT PROGRAM

Regenerative hydrogen-oxygen fuel cells have the potential of very high energy storage to weight ratios. But for minimum system weight, including energy converter, it soon becomes evident that a premium is placed upon efficiency. The aim of the present program is to develop electrodes which will allow higher efficiencies from the fuel cells while retaining the high energy to weight ratios.

One approach to the problem stated above is to develop a hybrid fuel cell which will retain in part the light weight characteristics of the hydrogen-oxygen fuel cell and which has far less electrode polarization associated with it. For this reason the major effort of this program will be devoted to work on the hydrogen-silver oxide "fuel cell". When charging or discharging on the lower plateau very high charge-discharge efficiencies have already been achieved. Methods will be sought to overcome some of the major disadvantages of the silver oxide electrode. Generally, it is possible to charge only a small fraction of the theoretical amount on the lower plateau and discharge only a small amount on the upper plateau, with a consequent energy loss. These limitations of the silver oxide electrode are believed to be connected with the high resistivity of Ag_2O. The first phase of the present program will include development and testing of several silver oxide electrodes doped with impurities for the purpose of decreasing this resistivity. Promethium doped silver (radioactive) is one example of the doped silver electrodes to be used. A correlation between electrode performance and silver oxide resistivity will be attempted.

An alternate approach to the problem would be the development of oxygen electrodes with more favorable polarization characteristics. It is expected that some of the developmental work on the silver oxide electrode will be applicable to the oxygen electrode. Therefore, some developmental work on the hydrogen-oxygen cell will be done.

The second phase of the program will be aimed at single cell development, based on some of the better electrodes studied in Phase I. The purpose is to maximize energy to weight ratios for these single cell units. The single cell development will be concerned mostly with the hydrogen-silver oxide cell.

2. FUEL CELL CONSTRUCTION

A fuel cell assembly has been constructed that is designed to measure individual electrode polarizations, in addition to the overall cell polarization, as a function of current density. The assembly has been completed very recently; therefore, no information has been obtained from it.

The design is essentially that of Oster (Ref. 1), except that the reference electrodes are opposite one another instead of opposite the working electrodes. The intention is to make at least one of the reference electrodes suitably stable for the work planned by preventing large currents from flowing in the immediate vicinity. That has been accomplished in the present design by placing the reference electrodes in the center and making the working electrodes in the shape of annular rings around them. The diameter of each reference electrode is 1.128 cm (0.444 inch) and, of each working electrode, 3.968 cm (1.562 inches) with a 1.728 cm (0.680 inch) hole in the middle. The latter dimensions give the working electrodes an area of exactly 10 cm^2, which facilitates the conversion from total current to current density.

The present cell is designed for silver oxide-hydrogen studies, but can be modified for use as a hydrogen-oxygen cell by replacing the back with one containing an oxygen storage cylinder. In either case, a bellows type pressure equilizer is used to maintain a pressure balance between the electrodes. Relief grooves maintain good pressure distribution to the backs of all four electrodes.

The cell contains a thermocouple well for measuring the temperature near the center of the cell and a pressure transducer in the hydrogen cylinder for measuring pressure changes during the course of a reaction.

3. ELECTRODE FABRICATION

Silver electrodes presently are being made by two general methods: sintering the powdered metal and reducing the oxide. The two methods are being used because the doping processes will include, in the first method, sintering a previously made alloy, and, in the second method, coprecipitation of oxides from aqueous solution. In all cases the silver electrodes will have a core of expanded silver about 0.37 mm thick. The total electrode thickness is about 0.6 mm.

Hydrogen electrodes are made by immersion plating platinum on porous nickel electrodes in a modification of the method previously employed at EOS.

4. INSTRUMENTATION

A constant current power supply-cycler unit has been designed for the present program. Its purpose is to automatically measure and record the fuel cell potential, the individual electrode polarizations, temperature, and pressure while the current is varied systematically on both charge and discharge. Beginning with an initial open circuit, the cycler goes through a charge cycle at 100 ma, 200 ma, 400 ma, 600 ma, etc., to 2 amps, in that order. It then goes to open circuit, through a discharge cycle at the same current settings as for the charge cycle, and returns to open circuit. At each setting the power supply maintains constant current, and the time spent at each position can be set for 1, 2, 3, 4, 6 or 12 minutes. It is tentatively planned to remain 3 minutes at each setting.

The entire unit has been completed except for a channel selector panel that will allow each channel to be scaled individually to the recorder. That feature will be ready within a few days.

5. RESULTS TO DATE

Experimental results have been confined to work with hydrogen-oxygen cells for the purpose of developing hydrogen electrodes with sufficiently good polarization characteristics for use with high performance silver oxide electrodes. The results so far are encouraging.

6. FUTURE PLANS

During the coming month it is anticipated that the electrode testing procedure will have been worked out. Several silver electrodes will have been made and tested, including doped silver electrodes. The work planned for the radioactive silver electrodes will commence sometime during the month after that.

REFERENCES

1. Oster, E.A., "Ion Exchange Fuel Cell Report No. 1," General Electric Co., Lynn, Massachusetts, for Contract No. DA-36-039-SC-89140, 31 December 1961.